Track Integrity Investigation

Washington Metropolitan Area Transit Authority (WMATA)

FINAL REPORT

Federal Transit Administration
U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

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Acronyms

CADWELD	Exothermic welding process named for Dr. Charles Cadwell
CAP	Corrective Action Plan
CENI	WMATA Office of Chief Engineering, Infrastructure
CMNT	WMATA Office of Rail Car Maintenance
CPDO	WMATA Office of Capital Program Delivery
DF	Direct Fixation
DOT	United States Department of Transportation
FTA	Federal Transit Administration
FWSO	FTA WMATA Safety Oversight
MMIS	Maintenance Management Information System
MSRPH	Metrorail Safety Rules and Procedures Handbook
OAP	Operations Administrative Procedures
POWR	WMATA Power Branch within Office of Systems Maintenance
QAAW	WMATA Office of Quality Assurance and Warranty
QICO	WMATA Quality and Internal Compliance Office
ROCC	Rail Operations Control Center
RTRA	WMATA Office of Rail Transportation
RWIC	Roadway Worker in Charge
RWP	Roadway Worker Protection
SAFE	WMATA Department of Safety and Environmental Management
SMI	Safety Management Inspection
SMNT	WMATA Office of System Maintenance
SOP	Standard Operating Procedure
SSO	State Safety Oversight
TIES	WMATA Department of Transit Infrastructure and Engineering Services
TOC	Tri-State Oversight Committee
TRST	WMATA Office of Transit and Structures
WMATA	Washington Metropolitan Area Transit Authority

1.0 Executive Summary

This report documents 12 findings from an investigation conducted by the Federal Transit Administration (FTA) Washington Metropolitan Area Transit Authority (WMATA) Safety Oversight (FWSO) team from March through June 2016 into the integrity of the Metrorail track system. These findings are reinforced by the FTA's preliminary determination of probable cause regarding the July 29, 2016, derailment near the East Falls Church Station, which indicates systemic safety deficiencies in the inspection, maintenance and repair of track. This report also describes 12 required actions WMATA must take to address the FWSO's findings. These requirements will be formally issued to WMATA separately through FTA Safety Directive 16-4.

Since FTA assumed temporary safety oversight of Metrorail in October 2015, WMATA has taken of number of critical steps to address safety deficiencies, but significant additional work remains to be done. The FTA supports these efforts and will continue to serve in an oversight role until the State of Maryland, the Commonwealth of Virginia and the District of Columbia stand up a new SSOA that meets the requirements of Federal law. The FTA, utilizing resources from across the U.S. Department of Transportation (DOT), carries out its safety oversight function by conducting inspections and investigations and directing WMATA to address deficiencies in a timely, adequate and systematic manner.[1]

The FWSO's track integrity investigation focused on 1) the adequacy of WMATA's track inspection process and resources, 2) the quality of WMATA's track standards, 3) the quality of training for track inspectors and maintainers, and 4) specific track maintenance and construction quality program issues.

The FWSO initiated this investigation in response to concerns stemming from:

- FWSO's review of WMATA's investigation into a major derailment that occurred on August 6, 2015, near Smithsonian Station;
- Several FWSO track inspections conducted in late February and early March 2016;
- FWSO's investigation into the March 14, 2016 arcing insulator fire at McPherson Square, including all 27 track locations where WMATA made emergency repairs during its self-imposed March 16, 2016 system-wide shut down; and
- Follow-up activity with WMATA to verify actions completed to address findings from FTA's Safety Management Inspection (SMI) and Safety Directive 15-1.

The FWSO focused its investigation on 10 specific track segments, including part of all six Metrorail lines, comprising over 60 miles of WMATA track in tunnels, at-grade, and on aerial structures. The majority of the FWSO's investigation activity took place between March 21 and April 15, 2016, with targeted follow-up field inspections taking place between April 28 and June

[1] FTA manages and coordinates the use of DOT-wide resources to ensure effective safety oversight of WMATA Metrorail. The DOT-wide team is referred to as the FTA WMATA Safety Oversight Team (FWSO).

30, 2016 on the Red Line and sections of the Orange/Blue/Silver Line, where WMATA completed urgent repairs to address initial FWSO findings. Results from FWSO inspections conducted at various SafeTrack locations since June 4, 2016, and findings from the Tri-State Oversight Committee (TOC) three-year review on track maintenance and training, have also been incorporated into this investigation.

As detailed in this report, the FWSO found that WMATA's track inspection program does not provide sufficient time for inspectors to adequately inspect their assigned territories, and does not fully account for differences in track types, locations, and the volume of train traffic. Also, the FWSO determined that WMATA does not prioritize the inspection importance of tracks, and that maintenance departments do not jointly review issues and safety concerns affecting the track structure to develop coordinated mitigations and assign limited resources to highest priority issues.

The FWSO also determined that WMATA's existing Track and Structures Inspection and Maintenance Manual (TRST 1000) contains outdated references, confusing and conflicting information on track standards and requirements, and does not clearly specify minimum safety standards. As a consequence, the procedure for WMATA track inspectors and supervisors to use the Manual to assess track conditions and clearly identify which conditions warrant speed restrictions is not well understood by track inspectors or track supervisors. Furthermore, the FWSO determined that WMATA's track inspectors require additional technical training and mentoring to overcome gaps in knowledge and experience.

The FWSO also identified track maintenance and construction quality issues, including the incorrect installation of anchor bolts on WMATA's direct fixation track fastening system to secure tracks on aerial structures and in tunnels. Also, the FWSO verified that much of the drainage system in WMATA's tunnel structure is not maintained in a state of good repair. Given the corrosive and deleterious effects of water on track and traction power infrastructure, FWSO found that drain maintenance should be a much higher priority in WMATA's overall track inspection and maintenance program. Finally, FWSO found that WMATA's Track Geometry Vehicle (TGV) could provide greater support to its overall track inspection program.

During the course of this investigation, track safety incidents continued to occur, notably arcing insulator events at Friendship Heights Station on April 27, 2016 and at Federal Center SW Station on May 5, 2016. As a result, the FWSO issued to WMATA two Immediate Action letters and Safety Directive 16-3 to focus WMATA activity on urgent improvements needed to enhance fire and life safety in the tunnels, to clarify the rules and protections afforded to workers on the right-of-way, to manage water intrusion and deficient track conditions in three specific locations, to enhance emergency preparedness and response to events in tunnels, and to ensure that safety is prioritized over operations when making decisions that affect passengers and employees.

Although WMATA is making progress, and has addressed many of the FWSO's immediate actions communicated in recent letters and Safety Directive 16-3, as discussed in this report, concerns remain regarding the quality of WMATA's track inspection and maintenance program. On July 29, 2016, a Metrorail passenger train derailed at a crossover outside of East Falls Church

Station. While the investigation is on-going, visual inspection conducted by the FWSO as part of the derailment investigation confirmed poor crosstie condition, loose and missing fasteners, and evidence of excessive lateral rail movement and wide gauge. These conditions clearly exceeded allowable safety parameters specified in WMATA's track safety standards, and were not found or addressed by WMATA personnel prior to the derailment. There is also evidence that WMATA was not adhering to established standards regarding the frequency of track inspections.

Notably, preliminary findings from the FWSO's investigation of the July 29th derailment are consistent with the FWSO findings set out in this report. Moreover, during the track integrity investigation, the FWSO highlighted concerns regarding the overall track conditions on the section of K-Line track from Vienna to Ballston, as crossties and other track components are reaching the end of their useful life. FWSO encouraged WMATA to include this track in its SafeTrack program, and specifically to prioritize work between East Falls Church to Ballston, as one of the first three SafeTrack surges. The particular interlocking involved in the derailment was not part of this initial surge because it was used to support single tracking operations. The interlocking at issue was originally scheduled for renewal later in the SafeTrack program, but, as a result of the derailment, WMATA completed renewal activities on August 1, 2016.

Also, in response to this derailment, WMATA has committed to performing detailed, supervisory pre-inspections of all turnouts, switches and crossovers required to be used to facilitate SafeTrack closures and single tracking operations. WMATA also will start an immediate special supervisory inspection of all crossovers on mainline tracks, including quality audits. The FTA expects WMATA to continue these actions through the remainder of the SafeTrack program, and will be monitoring the performance and quality of these inspections.

As directed by Safety Directive 16-4, WMATA must develop corrective action plans to address the findings of this report and related required actions. The FWSO will review and approve WMATA's work plans, and will monitor the agency's progress toward implementing the safety improvements. Additionally, the FWSO will work with WMATA to review and revise all pre-existing corrective action plans (CAPs), including CAPs related to track integrity, as appropriate to ensure that WMATA continues to make timely progress towards returning Metrorail to a good state of repair.

2.0 Introduction

This report documents the results of the track integrity investigation conducted by the Federal Transit Administration (FTA) between March 21 and June 30, 2016 on the Washington Metropolitan Area Transit Authority (WMATA) Metrorail system. The FTA WMATA Safety Oversight (FWSO) Office initiated this investigation in response to recurrent track deficiencies and defects identified during FWSO's track inspections at WMATA, and to support follow-up on track issues identified as part of the FWSO's Safety Management Inspection (SMI). The FWSO also used this investigation to explore systemic issues identified as part of WMATA's investigation into a derailment near Smithsonian Station on August 6, 2015 and Tri-State Oversight Committee (TOC) three-year review into track maintenance and training at WMATA.. Finally, this report also addresses preliminary findings from the FWSO's investigation into the July 29, 2016 derailment near East Falls Church.

2.1 Background

The WMATA Metrorail system is the second largest rail transit system in the United States with 269.8 total track miles, including 136.6 miles at grade, 18.4 miles on elevated structures, .5 miles elevated on fill, 3.1 miles open-cut tunnel, and 111.2 miles of subway tunnels.[2] WMATA's track infrastructure includes track bed structure (sub-base, tunnel inverts, bridges, or other sub-structures), running rails, ties and ballast or direct fixation system, fasteners, special trackwork, such as switches and turnouts, drainage system elements, traction power contact "third" rail, traction power feeder cables, conduits, manholes and potheads. Impedance bonds are also located in the track bed and connected to the running rails.

WMATA manages the integrity of this critical infrastructure through a series of inspection, testing and maintenance standards and programs, renewal programs, and engineering assessments and modifications. Within WMATA's Transit Infrastructure and Engineering Services (TIES) Department, Track and Structures (TRST) is responsible for track inspection, maintenance, and production, including the track bed, running rails and third rail, and supporting infrastructure. Within System Maintenance (SMNT), the Power (POWR) Branch and the Automatic Train Control (ATC) Branch maintain key elements of the positive and negative return systems, respectively, for the traction power system. The Capital Project Development Office (CPDO) is responsible for the testing, replacement, and upgrade of traction power cables and other traction power system elements, and, recently also initiated a traction cable inspection program. The Office of Chief Engineering, Infrastructure (CENI) provides critical engineering services to support each department in managing engineering modifications and site assessments, upgrades, and addressing changing infrastructure conditions. CENI, in coordination with TRST, also manages the TGV program.

WMATA's maintenance, engineering and capital project departments and branches have adopted safety standards and manuals, engineering procedures, and an approach to issuing work instructions and site-specific drawings to govern most activities performed to ensure the integrity of the track and traction power system. WMATA provided the FWSO with copies of these

[2] As reported by WMATA to the National Transit Database (NTD).

materials, and supported multiple meetings with FWSO's experts to review specific requirements and practices and to clarify WMATA's unique conventions and classification systems.

2.2 Purpose

This investigation report focuses on: 1) the adequacy of WMATA's track inspection process and resources, 2) the quality of WMATA's track standards, 3) the quality of training for track inspectors and maintainers, and 4) specific track maintenance and construction quality program issues. This investigation report does not contain itemized inspection findings relating to specific track defects but rather addresses systemic issues limiting the effectiveness of WMATA's track inspection and maintenance program. This report builds on other findings issued to WMATA in recent FWSO communications, including the April 18 and May 11 Immediate Action letters and Safety Directive 16-3, regarding track system inspection and maintenance. The FWSO's previous communication on these issues is available at:

- April 18, 2016 Letter, Immediate Actions to Address Fire/Life Safety and the Protection of Workers on the Right-of-Way, https://www.transit.dot.gov/regulations-and-guidance/safety/fta-letter-wmata-track-safety-blitz-immediate-actions-april-18-2016.
- May 11, 2016 Letter, Urgent Repairs Required Prior to Start-up of SafeTrack Plan, https://www.transit.dot.gov/regulations-and-guidance/safety/fta-letter-wmata-urgent-repairs-required-prior-start-wmata-safe.
- Safety Directive 16-3 Required Actions to Address Persistent Critical Open Safety Findings Issued to WMATA (May 7, 2016), https://www.transit.dot.gov/regulations-and-guidance/safety/fta-safety-directive-16-3.
- Letter from FTA Acting Administrator WMATA General Manager re: FTA Safety Directive 16-3 (May 18, 2016), https://www.transit.dot.gov/regulations-and-guidance/safety/wmata-response-fta-safety-directive-16-3.

2.3 FWSO's Inspection Program

While this investigation report focuses on systemwide issues, the FWSO shares all deficient track conditions identified during FWSO's track inspections with WMATA in formal inspection reports, typically transmitted to WMATA within 3 days of the inspection. In addition, the FWSO's inspectors telephone and email WMATA supervisors and leadership regarding the identification any serious items requiring priority action. Also, since WMATA track supervisors typically accompany FWSO's inspectors, defective conditions identified by the FWSO's inspectors are often called in for corrective maintenance immediately from the track wayside.

Through the course of these inspections, since December 2015, the FWSO has issued over 600 remedial actions to WMATA to correct deficient track conditions. While FWSO has verified closure of approximately 20 percent of these remedial actions through re-inspection, the FWSO and WMATA are currently establishing a system to reconcile maintenance work orders with FWSO remedial actions, so WMATA can report on the closure of remedial actions monthly. The FWSO anticipates that this system will be in place by the end of September. (The FWSO will not close open remedial items issued to WMATA unless verified through a completed WMATA work order or re-inspection in the field.) In the interim, to the extent possible, the FWSO

continues to monitor WMATA action to address identified track defects through follow-up re-inspections and review of work order scheduling in WMATA's maintenance database.

2.4 Schedule and Major Activities

The FWSO formally notified WMATA regarding the decision to conduct an investigation into track integrity issues in early March. The FWSO then worked closely with WMATA to complete a document request and to schedule interviews, field observations, inspections, and demonstrations regarding the condition of the track and traction power infrastructure and the performance of key equipment, information management systems, technology, and personnel.

The majority of the FWSO's investigation activity took place between March 21 and April 15, 2016, with targeted follow-up field inspections taking place between April 28 and June 30, 2016 on the Red Line and sections of the Orange/Blue/Silver Line, where WMATA completed urgent repairs to address initial FWSO findings. In addition, largely in response to concerns with track quality identified by the FWSO and WMATA in March and April, WMATA expedited its SafeTrack program to prioritize efforts to complete critical maintenance and rehabilitation of its track system. Since June 4, 2016, FWSO personnel have conducted multiple inspections of each SafeTrack surge location to verify the completion and quality of prioritized work.

WMATA participated in two agency-wide meetings to discuss FTA's findings in April and May, and completed a factual review of this report in July.

2.5 Related Safety Findings and Required Actions

Over the last year, the FWSO has issued a number of findings and required actions to WMATA regarding track and traction power inspection and maintenance issues. This report acknowledges these previous findings and the status of WMATA's implementation of approved corrective action plans in addressing them.

2.5.1 Safety Management Inspection

During the 2015 SMI, the FWSO evaluated the WMATA Metrorail system's maintenance and inspection programs for critical infrastructure, including track and traction power systems. The FWSO also completed a general assessment of track and third rail conditions at locations throughout the system.

On June 17, 2015, as part of Safety Directive 15-1, the FWSO issued several required actions for improvements to these programs and the condition of this infrastructure, directing WMATA to ensure that maintenance and inspection crews have sufficient access to the track to complete their work and that the work is adequately supervised, that inspector and maintainer training and quality programs are improved, and that enhancements are made to WMATA's roadway worker protection (RWP) program. WMATA has corrective action underway to address the following required actions:

- R-4-27-a: For all major departments with inspection and maintenance responsibilities for critical infrastructure, WMATA must establish and/or update a preventive maintenance and inspection testing quality audit process to ensure compliance with established maintenance and testing practices, and to monitor missed or incomplete preventive maintenance activities and/or inspections. (Status: Work underway, due December 2017.)

- R-4-28-a: WMATA must review the workload and inspection territory assigned to track inspectors, and leverage non-track inspectors to perform watchman duties. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-4-32-a: WMATA must ensure that each department within Transit Infrastructure and Engineering Services creates a formal program of Supervisory inspections to observe maintenance, look at quality of work in the field, and formally intervene to evaluate, re-train (if necessary), and enhance the professional development of employees. (Status: Closure request under FWSO review.)

- R-7-42-a: WMATA operating and maintenance departments must work together to develop a strategy to more actively analyze, review, and assess rail operation and maintenance data from a safety perspective. (Status: Work underway, due March 2018.)

- R-2-16-a: WMATA must conduct a coordinated study to prioritize technical training needs for maintenance personnel, and operations training for Rail Traffic Controller, Train Operators, and Field Supervisors. (Status: Work underway, due August 2017.)

- R-2-16-d: WMATA must establish formal guidance for maintenance employees responsible for providing on-the-job training. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-3-23-a: WMATA must ensure that a process is in place for identifying and scheduling sufficient track time to complete required inspection, testing and maintenance activities. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-3-24-a: WMATA must establish firm limits on minimum track time for inspection, testing and maintenance activities per month, and revisit limits annually. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-3-25-a: WMATA must develop and implement staffing plans to eliminate maintenance work orders backlogs and manage on-going workload in track and structures, traction power, communications, and automated train control. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-3-26-a: WMATA must improve interdepartmental coordination and communication to take full advantage of track time. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-8-44-a: WMATA must complete required submittals to FWSO to close-out 2012 Safety and Maintenance Audit Recommendation #2 relating to WMATA's rail de-stressing program. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

- R-8-44-b: WMATA must conduct an independent engineering assessment regarding the Critical Rail Neutral Temperature and Preferred Rail Laying Temperature Range established in "Track Maintenance & Inspection Manual" Revision 6 approved on March 16, 2015, to ensure that the likelihood of rail buckles is decreased. WMATA's proposed range (+10 to -19 degrees below the preferred rail laying temp of 95) is 9 degrees below WMATA's original measures and does not conform to industry standards and recommended practices. (Status: Submitted to FWSO for closure; FWSO is requesting additional action.)

2.5.2 August 6, 2015 Derailment Investigation

Two months before FTA (through its FWSO) assumed temporary safety oversight responsibility for Metrorail, WMATA Train #412 derailed on the D-line at Curve 306 near Smithsonian Station. While there were no injuries as a result of this incident, the derailment caused damage to multiple components of the track and trackbed, including track, rail fasteners, clips and bolts, ATC and power equipment. The derailment also damaged rail car wheels and trucks, forcing the suspension of service on the Orange/Blue/Silver Lines for most of the day.

In its direct, temporary safety oversight capacity of WMATA (in accordance with Safety Directive 16-1), the FWSO initiated a review of WMATA's investigation findings and corrective action plans. Concurrent with its review of this draft report, FTA conducted track inspection verification activities at WMATA in November and December 2015, and reviewed the triennial track maintenance audit issued by the TOC in December 2015. The FTA and TOC conducted several meetings regarding this derailment, and the condition of WMATA's track infrastructure in general. The FTA also reviewed the remedial actions taken by the TRST in response to this accident, and the status of the track-related corrective action plans developed by WMATA in response to the FTA's SMI.

On February 16, 2016, the FTA requested additional action from WMATA to complete this investigation. WMATA responded to FTA on March 16, 2016, and elements of this response were also discussed during the FTA's subsequent track integrity investigation. WMATA identified the following root causes of the August 6, 2015 derailment:

1. Failure of WMATA's TIES and TRST leadership to manage the TRST trackwalker inspection and corrective maintenance processes effectively; and
2. Failure of management to manage the TRST TGV track inspection and corrective maintenance program and processes effectively. The deficiencies in the TRST track walker and TGV track inspection and corrective maintenance program and processes encompass the following:
    a. Ineffective management by TRST of data gathered from the field as well as failure to properly schedule and prioritize maintenance with this information,

b. The lack of an approved procedure for the TGV inspection program and process, as required by Section 12.3.3 of the System Safety Program Plan, and
c. Ineffective management and oversight of maintenance management training, procedures and policy.

In response to the FWSO's request, WMATA revised the report to include additional information on the underlying metallurgical, track construction, and maintenance quality issues that contributed to the deficient track conditions. WMATA also provided additional information on potential deficiencies in the training, qualification and certification of track inspectors. Also, WMATA clarified actions underway to determine the exact number of preventive maintenance work orders completed by the Track Maintenance Branch, and the apparent conclusion, provided on Page 20 of the draft report, that preventive maintenance programs "are on the back burner." Finally, WMATA initiated a series of assessments regarding track quality and condition which ultimately resulted in the SafeTrack program, and also initiated a series of reviews by contractors and peers to identify opportunities to improve track inspection procedures, training, and data quality.

2.5.3 Track Inspection "Safety Blitz" Results

Between March 21 and April 15, 2016, seven (7) teams, comprised of DOT inspectors, track and traction power engineers, and track and traction power subject matter specialists, inspected over 60 miles of WMATA track, including running rails, contact rails, insulators, cables and assemblies, track beds, ties, fasteners, fixation systems, switches, turnouts, crossovers, and all 27 locations where WMATA made repairs to its traction cable power electrification system on March 16, 2016.

FWSO's teams also reviewed maintenance records and work orders, engineering specifications, and observed roadway worker safety training and corrective maintenance work performed during WMATA's OWL shift. Finally, FWSO's teams evaluated training materials and programs for WMATA's track inspectors, track maintainers, and traction power technicians.

While FWSO's teams found that track conditions in many locations generally conformed to WMATA's track safety standards, out-of-compliance conditions were also identified, including rows of missing fasteners and defective ties, rail corrosion, and missing bolts and excessive wear in switches and crossovers. In all, over three weeks between March 21 and April 15, 2016, FWSO's inspection teams identified almost 400 defects in track conditions, including 7 "black" conditions in three locations that required WMATA to take track out of service and 7 additional "red" conditions that required WMATA to impose speed restrictions.

Examples of typical defects found by FWSO's teams that require repair include the following:

- Missing direct fixation fasteners,
- Rail surface spalling,
- Missing and defective ties,
- Rail corrosion,
- One cracked third rail,
- Broken third rail support brackets,

- Loose switch rod bolts,
- Missing track fasteners and clip clusters,
- Rail shelling,
- Standing water and blocked drains within the gauge of the track,
- Fastener defects in standing water,
- Joint clip defects,
- Rail and other debris stowed on safety walks,
- Missing third rail cover boards,
- Lights not working at Emergency Telephone Stations,
- Exposed wires at impedance bonds,
- Broken studs, missing stud nuts, and cracked grout pads,
- Broken frog fasteners, and
- Tunnel lighting defects.

At many locations, FWSO's teams found the irregular or inappropriate installation of stud bolts designed to anchor the direct fixation system. FWSO also noted violations of fire/life safety standards related to expired fire extinguishers, blocked safety exists and catwalks, obscured or missing safety signage, inadequate tunnel lighting, non-functioning Emergency Trip Station (ETS) boxes, and missing or poorly stocked emergency boxes for switch repair.

During the course of its investigation, FWSO also re-inspected previous defects identified to assess repairs. The FWSO found that two defects (3rd rail joint at Mt. Vernon and tread wear on frog in Fort Totten interlocking) had been repaired in conformance with WMATA track standards. However, the FWSO also noted a defective drainage condition at the location near Mt. Vernon Station. This condition had not been corrected at the time of the FWSO re-inspection, and was the ultimate root cause of the defective gauge measurement.

Throughout the course of the investigation, FWSO also identified four direct fixation (DF) fastener defects that included more than the 120 inch maximum distance allowed between effective fasteners. According to WMATA maintenance standards anything over 120 inches requires that a "black" (out of service) condition be placed on the track. However, WMATA track supervisors at the location with FWSO's team determined that 15 mph speed restrictions would be sufficient for two of these three conditions. WMATA did remove from service the track with the third instance of missing fasteners. This short section of track in the crossover between two switches measured 456 inches (over 21 feet) between effective fasteners. This is almost four times the minimum allowed by WMATA's maintenance standards. WMATA requires a twice weekly mainline walking inspections and monthly switch inspections. In the course of one month, this area would have been inspected, at a minimum, nine times, yet this condition was not identified or addressed.

During the last week of March and the first week of April, FWSO's teams also inspected all 27 locations where emergency repairs were made to traction power cables as a result of WMATA's March 16, 2016 emergency shutdown. FWSO inspections of traction power cable repairs generally found that the repairs made on March 16, 2016 were made in conformance with WMATA engineering specifications, and infrared temperature monitoring of the cables and connections did not indicate any large swings from ambient temperature. The FWSO did identify

two locations were additional engineering evaluation was warranted, and also reported four other cable conditions to WMATA for repair.

Most significantly, FWSO found multiple water leaks between the Potomac Avenue and Stadium-Armory stations, including a gushing leak at the safety catwalk and a smaller leak just above a newly installed boot and a cable. Additionally, between McPherson Square and Farragut West, and Stadium-Armory and L'Enfant Plaza, FWSO discovered damaged or completely cut C-bonds at running rail joints. Specific findings identified and reported to WMATA include:

- Cable connectors on the slab at crossover kicker rails where adjustments must be made and/or support provided beneath the cable/termination to separate the termination from the concrete.
- Cables laying on concrete slab, where WMATA could potentially install cable standoffs with insulators to separate cable from concrete.
- Duct line transition from concrete slab was not always protecting the cable – some areas used heat shrink tubing, link seal or OZ Gedney bushings.
- Several third rail anchors were under stress or broken.
- Cover boards missing.
- Debris and trash embedded in track beds near end approaches potentially within reach of sparks from collector shoes.
- Insulator contamination.
- Expansion joint inspection showed that replacement cable in several locations is under stress and lacked drip loop configuration.
- In the area of the two kicker rails, third rail cable potheads were observed to be laying directly on the ground.
- Unusual wear patterns and multiple knocked off collector shoes were noted at the end approach near the Farragut West station platform.
- Signs of electrical arcing on tunnel wall between Federal Center and Capitol South.

FWSO's team also found a third rail tensioner under stress, and an additional location with expansion joint cables with slashed insulation where cables are lying on the ground with some tie plates on them. The FWSO has since initiated a separate special investigation, and will be issuing a separate investigation report on WMATA’s traction power electrification system.

Finally, through the course of this inspection activity, FWSO observed numerous violations of WMATA’s RWP program. FWSO’s teams found that train operators did not consistently follow speed restrictions verbally conveyed over the radio. As noted in the FWSO’s SMI, formal repeat-backs are not always required, and FWSO’s teams experienced instances where trains passed locations with newly imposed speed restrictions at greater than 15 miles per hour.

As explained in Section 2.3 above, all inspections conducted to support this investigation resulted in formal inspection reports that were provided to WMATA. Inspection reports are uploaded to a shared folder, and also emailed to key leadership in WMATA’s track and safety departments. Major safety concerns are communicated immediately. The FWSO also conducts a verbal briefing with WMATA staff at the conclusion of each inspection. Specifically for the track integrity investigation, the FWSO also conducted two meetings with WMATA’s senior

management and technical leadership, on April 11 and May 19, 2016, to review major findings, issues and concerns, and to discuss and verify the development of WMATA's track quality improvement program and the new SafeTrack program, as well as steps that WMATA is taking to improve its track inspection and maintenance program.

2.5.4 Immediate Action Letters and Safety Directive 16-3

Based on the results of this investigation, and a set of additional arcing insulator events occurring at Friendship Heights Station on April 27, 2016 and at Federal Center SW Station on May 5, 2016, the FTA issued two (2) Immediate Action letters, on April 18 and May 11, 2016, respectively, and *Safety Directive 16-3: Required Actions to Address Persistent Critical Safety Concerns* on May 7, 2016. Through this communication, FWSO focused WMATA attention on urgent needed improvements required to enhance fire/life safety in the tunnels, to clarify the rules and protections afforded to workers on the right-of-way, to manage water intrusion and deficient track conditions in three specific locations, to enhance emergency preparedness and response to events in tunnels, and to ensure that safety is prioritized over operations when making decisions that affect passengers and employees.

Over the last two months, the FWSO and WMATA have worked through many of these issues and concerns, particularly regarding fire/life safety equipment and features in tunnels, and the need to reinforce RWP rules compliance. The FWSO verified that WMATA has completed several of the required actions, and continues to monitor WMATA's responses to Safety Directive 16-3, and the immediate action letters, including the prioritization of specific locations and repairs identified by the FWSO in WMATA's SafeTrack program and WMATA's on-going commitment to prioritize safety over service in managing response to specific track and traction power incidents and related service disruptions.

2.5.5 July 29, 2016 Derailment

On July 29, 2016, a Metrorail passenger train derailed at a crossover outside of East Falls Church Station. While the investigation is on-going, visual inspection conducted by FWSO as part of the derailment investigation confirmed poor crosstie condition, loose and missing fasteners, and evidence of excessive lateral rail movement and wide gauge. These conditions clearly exceeded allowable safety parameters specified in WMATA's track safety standards, and were not found or addressed by WMATA personnel prior to the derailment. There is also evidence that WMATA was not adhering to established standards regarding the frequency of track inspections. Failure to comply with these standards may have contributed to the derailment.

Notably, preliminary findings from FWSO's investigation of the July 29th derailment are consistent with the FWSO findings set out in this report. Moreover, during the track integrity investigation, FWSO highlighted concerns regarding the overall track conditions on the section of Orange/Silver Line track from Vienna to Ballston, as crossties and other track components reach the end of their useful life. FWSO encouraged WMATA to include this track in its SafeTrack program, and specifically to prioritize work between East Falls Church to Ballston, as one of the first three SafeTrack surges. The particular interlocking involved in the derailment was not part of this initial surge because it was used to support single tracking operations. The

interlocking at issue was originally scheduled for renewal later in the SafeTrack program, but, as a result of the derailment, WMATA completed renewal activities on August 1, 2016.

In the immediate aftermath of the derailment, WMATA issued a preliminary report of investigation. According to the preliminary report, "the causal factor in this event is that track ties at the [Point of Derailment] were deteriorated to the point where they were no longer effective in restraining the dynamic lateral forces transferred to the track by train 602." Working with WMATA and the FTA, the National Transportation Safety Board (NTSB) conducted a limited investigation of this derailment, and in the briefing they provided to Congressional staff for members of Congress from the region, as well as committee staff with oversight for transportation safety, the NTSB did not state probable cause, but did convey findings of fact regarding the extent of wide gauge at the location of the derailment and the presence of a severe defective tie condition in the derailment area.

In response to this derailment, WMATA has committed to performing detailed, supervisory pre-inspections of all turnouts, switches and crossovers required to be used to facilitate SafeTrack closures and single tracking operations. WMATA also will start an immediate special supervisory inspection of all crossovers on mainline tracks. Finally, WMATA will perform quality audits of both SafeTrack and mainline supervisory inspections. The FTA expects WMATA to continue these actions through the remainder of the SafeTrack program, and will be monitoring the performance and quality of these inspections.

2.4.6 WMATA Action

In response to the August 5, 2015 derailment, the findings of the FWSO's SMI, and WMATA's ongoing analysis regarding the condition of its infrastructure, the FWSO finds that WMATA is taking many actions to improve the quality of its track inspection and maintenance programs. WMATA has established the SafeTrack program to address some of its most track significant maintenance backlog. WMATA is also proposing a new service schedule to accommodate additional time to address track maintenance requirements.

WMATA is in the process of conducting several external reviews, by contractors and the American Public Transportation Association (APTA), to assess the resources and requirements for its track and structures maintenance program. WMATA is overhauling its track safety standards and its track inspection training, and is working with another contractor to conduct a systemwide track inspection and to overhaul and correct the defect entries in WMATA's Maintenance Management Information System (MMIS) database. WMATA also is expanding its TGV program and training. The FWSO hopes that the findings and required actions outlined in this report will assist WMATA in focusing its attention on safety-critical priorities as it develops and implements new programs to enhance its track inspection and maintenance programs.

3.0 Track Inspection and Maintenance

At WMATA, direct fixation track is the standard method of construction for tracks on aerial structures and in tunnels. Direct fixation track is a "ballastless" track structure in which the rail is mounted on direct fixation fasteners that are attached to a concrete deck, slab, or invert. Ballasted track is used for most at-grade and yard locations.

The map below depicts the usage of the WMATA track system in terms of million gross tons per year. The track segments with thicker, redder lines experience the greatest volume of train traffic with the most weight. The Rosslyn to D98 corridor, the most used track segment, with all 6-car train operation, annually manages 37 million gross tons in trains and passenger weight. When WMATA moves to 100 percent 8-car train operations, using the new 7000 series vehicles, this segment will manage up to 55 million annual gross tons. This segment also requires the greatest level of attention in terms of track inspection and maintenance.

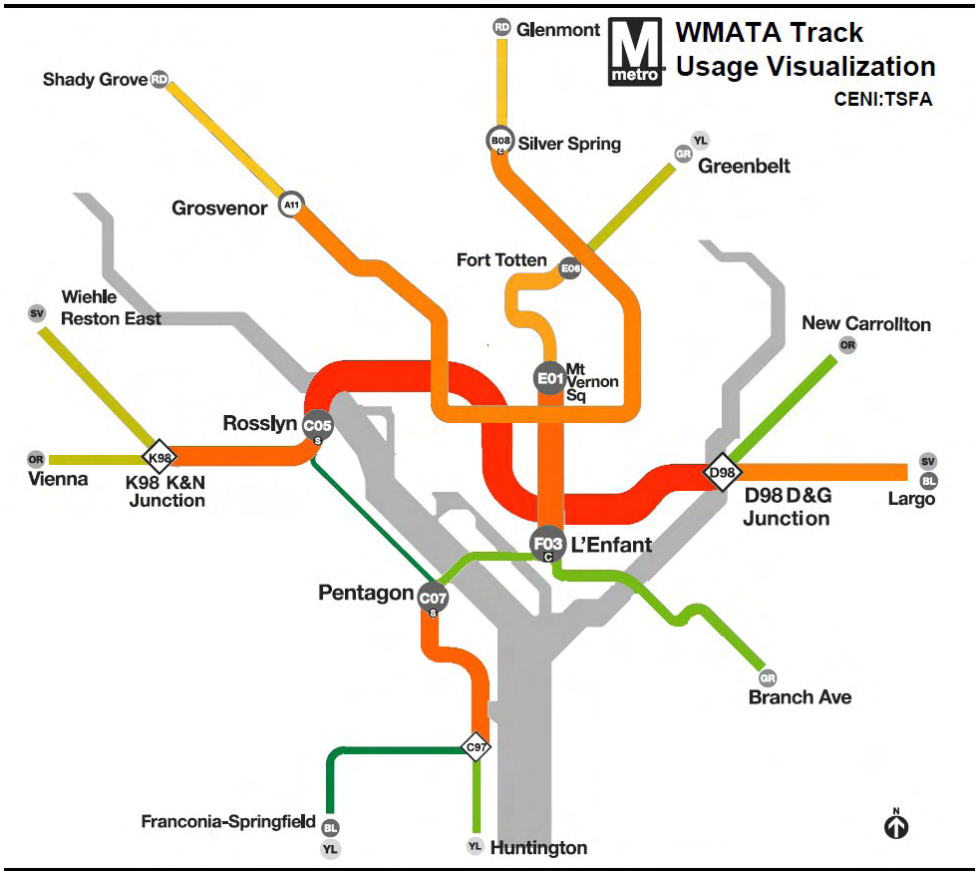

Figure 1: WMATA Track Usage Visualization

3.1 Track and Structures Department

TRST is responsible for track inspection, maintenance, and production on the WMATA system. The following policies and procedures govern all track work:

- TRST1000 – Track Maintenance and Inspection Manual. Revision 6. January 1, 2015.
- TRST 2000 – Track and Structures Maintenance Control Policy. Revision 6. February 20, 2015.
- Metrorail Safety Rules and Procedures Handbook. April 9, 2015 (Electronic Update).
- Operations Administrative Procedure 208-01. Track Maintenance Management, Maintenance of Way. July 31, 2006.
- Operations Administrative Procedure 208-02. Structures Maintenance Management, Maintenance of Way. July 31, 2006.
- Roadway Worker Protection Manual. June 2014.

Within TRST, the Track Inspection Branch (TKIN) has responsibility for inspecting WMATA tracks and supporting infrastructure for defects. Rail transit agencies must inspect tracks to detect defects, monitor defect progression, and take corrective action when required to ensure the safety of employees and passenger operations. There are two types of track inspection: (1) visual inspection performed by inspectors generally on foot but sometimes by train or high-rail vehicle at slow speeds, and (2) automated track inspection, performed by a vehicle or piece of equipment using ultrasonic or electromagnetic methods. Many large rail transit agencies, such as WMATA, combine the two types of inspection, with visual inspection used as the primary, day-to-day means for ensuring the safe condition of the track, and automated inspection supporting the identification of difficult-to-detect defects and providing an annual or semi-annual assessment of overall track integrity by line or section.

At WMATA, track inspections, accomplished on foot daily, provide the primary method for observing and recording deterioration that could adversely affect Metrorail operations. WMATA's TRST 1000 Manual requires TKIN to performs the following walking inspections:

- Visual mainline track inspections twice weekly.
- All mainline switches, turnouts and special trackwork, no less than monthly.
- All yard and yard switches, monthly.

TKIN also coordinates, but does not manage, automated inspections i.e., rail flaw, lateral load, geometry, ultrasonic and component assessment with the Chief Infrastructure Engineer (CENI) and vendors. Using the TGV, ultrasonic rail inspection is performed a minimum of twice a year and automated track geometry inspection, rail surface condition inspection and rail wear condition inspection are performed four times per year for the entire system. WMATA is still finalizing its approach to incorporating the TGV into its overall inspection plan and program.

While track and structure inspections are performed by several methods, all inspection methods share a common approach to describing conditions as it relates to a degree of serviceability. These four levels of serviceability are

- Fully Operational (Green/Minimal Wear),
- Operational (Yellow/Damage and/or Wear),

- Restricted Operations (Red/Exceeds Tolerances), and
- Safety Hazard (Black).

Depending on the level of serviceability, there are prescribed actions required by the TRST 1000 manual, ranging from speed restrictions to placing the section of track out of service. Speed restrictions are applied only when the components are defective from a safety point of view (i.e. when the safety of the track may be compromised). For components that are defective from a maintenance point of view, speed and/or other restrictions are imposed at the discretion of the track supervisor.

The Track and Structure Maintenance Branch (TSMN) is responsible for maintaining all mainline track, special track work and yards. The Track and Structures Maintenance department is divided into two branches. (1) Track Maintenance (TKMN) and (2) Structures Maintenance (STRC). TKMN is further divided into two divisions (North and South). The TKMN Groups (North and South) are responsible for performing corrective maintenance on defects to tracks and other supporting infrastructure. Maintenance Managers review the work orders opened by Track Inspectors, assign labor codes to each work order, and set priorities for corrective maintenance work for the next 24 hours.

The Track Production Capital Program Branch (TPCP) has responsibility for performing all capital budget track work system-wide. This includes, replacement of ties, turnouts, fasteners, running rail, floating slab and third rail insulators. TKMN work crews also support TPCP.

3.2 Track Inspection

Track inspectors are required to inspect every mile of the Metrorail mainline system twice per week, recording defects affecting any track asset within their field of view. These defects range from items requiring immediate attention (e.g. a broken frog or a bolt hole break at a joint) to slowly deteriorating conditions that need to be monitored (e.g. mild spalling on the rail head on a section of track). Track inspectors complete written reports, and log defects in WMATA's enterprise asset management system (Maximo) with the objective of building a defect history that can be queried and visually displayed through the authority's rail maintenance planning software (Optram), alongside data from the other inspection sources.

The TRST 1000 manual specifies that applicants to the track inspector position must have at least one year of track-related experience. Accepted applicants complete 7 weeks of classes spread out over an 18-week training period, and upon passing several written quizzes and field assessments, are certified as track inspectors Class D. After every year of satisfactory performance, track inspectors are eligible to take a promotional test to qualify for the next level (C, B, A, and finally class AA, at 5 years of total trackwork experience). The promotional test is a term of the union contract and does not emphasize track inspection skills. However, WMATA track inspectors also are required to re-certify as track inspectors at their current level every two years, with a written test and field demonstration.

Table 1 below shows the distribution of experience for the TKIN group. TKIN has seen a steady increase in the number of inspection personnel since 2010 (from 43 to 59), largely due to new

positions to support the Dulles Phase 1 (Silver Line) and the new Special Inspection Group (SIG), which supplements daily track inspection by targeting on specific issues or activities, such as switch and yard inspections. Dulles Phase II, projected to open by 2019, will add an additional twelve miles, requiring at least 4 more track inspectors.

Table 1: Track Walking Experience (March 2016)

Class	Number
A (5+ years)	21
(4 years)	0
(3 years)	9
(2 years)	13
(1 year)	11
Trainee	5
Total	59

Inspection of the Metrorail system is divided into geographical regions: Dulles, which covers the N-Line, which opened in July 2014; Brentwood, which covers the A- and B-Lines; Branch Avenue, which covers the E-, L- and F-Lines; New Carrollton, which covers the D- and G-Lines, and the C-Line from Metro Center to Rosslyn; and Alexandria, which covers the C-Line from Arlington Cemetery through Huntington, the J-Line, and the K-Line.

These geographic regions are further sub-divided into 25 track inspection territories. Each 2-person track inspection team is assigned a single territory that ranges in length from just over 2 miles to 6 miles. Each 2-person track inspection team is responsible for inspecting all running rails, third rails, track switches, and supporting components, including clips, fasteners, drainage system, and other related components within its territory. See Figure 2 on the next page.

After the FWSO's SMI, and extensive discussions with WMATA regarding resources for track inspection, in December 2015, WMATA revised the length of its track inspection territories, adding one new territory, ensuring no single territory was longer than 6 miles, and bringing the average territory length down to 4.3 miles from 5.7 miles. See Figure 3 below.

The 2-person crews typically inspect Track 1 of their assigned territory on one day, and Track 2 of their assigned territory on the next day. Special inspections are also conducted in their assigned territories for switches, special trackwork, and pocket tracks. In the middle of the week, track inspectors may also perform light maintenance, such as bolt torqueing or debris or vegetation removal. Track inspection during peak operating periods (7am- 10am, and 4pm-7pm) is no longer WMATA's policy, due to increased train frequencies, which impact effectiveness and worker safety. Walking track inspection is largely accomplished in a 4-hour interval between the peak periods (10am – 2 pm). Track inspections are not currently conducted at night, with two exceptions: the Greenbelt test track and the B35 double-crossover, where clearance issues at these locations prevent track inspection under traffic.

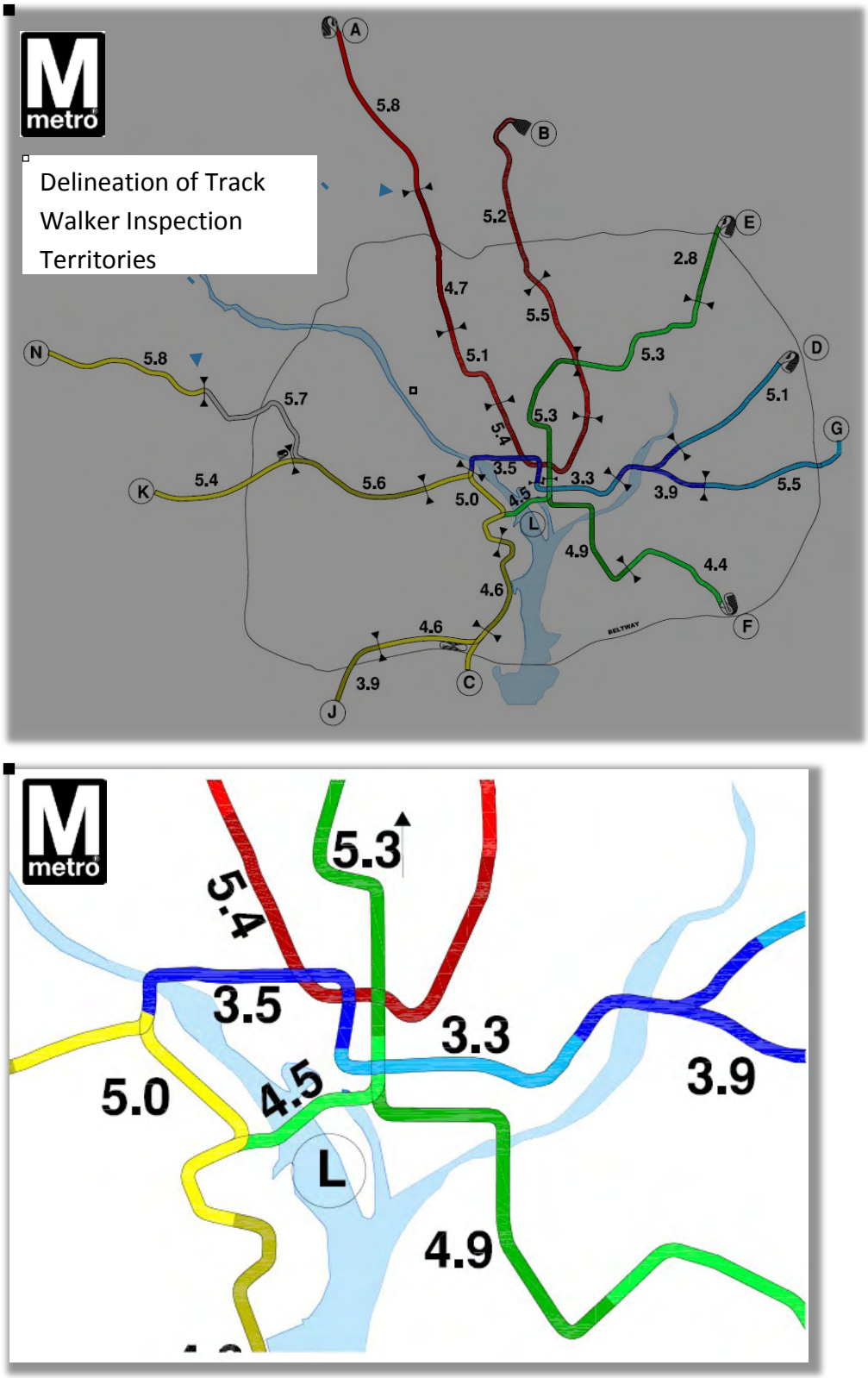

Figure 2: WMATA Track Inspection Territories, 2016

	2015 Track Inspection Territories				2016 Track Inspection Territories			
	Segment	Miles	MGT*	**Type**	**Segment**	Miles	MGT*	Type
Rosslyn - D98 Core	D13-D09 (D98)	5.5	16	At-Grade	D10 - D13	5.1	14	At-Grade
	D09 (D98) -D05	3.93	37	Tunnel and Aerial	D08 - D10, G-Line	3.9	37	Aerial and Tunnel
	D05-D01	2.2	37	Tunnel	D08 - D02	3.3	37	Tunnel
	C05-C01	2.7	37	Tunnel	C05 - D02	3.5	37	Tunnel
A and B Line	A15-A11	7.2	21	At-Grade	A15 - A12	5.8	21	At-Grade
	A11-A07	5.8	27	Tunnel	A12 - A09	4.7	27	Tunnel and At-Grade
	A07-A01	5	27	Tunnel	A09 - A04	5.1	27	Tunnel
	B01-B35	1.3	27	Tunnel and Aerial	A04 - B04	5.4	27	Tunnel
	B35-B07	6	27	At-Grade and Aerial	B04 - B08	5.5	27	At-Grade
	B07-B11	6.5	18	Tunnel and At-Grade	B08 - B11	5.2	16	Tunnel
and F Line	E10-E06	7.2	16	Tunnel and Aerial	E09 - E10	2.8	16	At-Grade
	E06-E01	5.4	16	Tunnel	E06 - E09	5.3	16	Tunnel and Aerial
	F01 - F03	1	30	Tunnel	E06 - F02	5.3	30	Tunnel
	F03 -F06	2.6	15	Tunnel	F02-F03 and L Line	4.5	30	Tunnel and Aerial
	F06 - F11	6.8	15	At-Grade	F03 - F08	4.9	15	Tunnel
					F08 - F11	4.4	15	At-Grade
Line	G05-G01	7	27	Tunnel and Aerial	G01 - G05	5.5	27	Tunnel and Aerial
K Line	K08-K05	7.5	17	At-Grade	K08 - K06	5.4	17	At-Grade
	K05-K01	5	30	Tunnel	K06 - K02	5.6	30	At-Grade and Tunnel
N Line	N06-N93 (Wolf Trap)	3.7	17	At-Grade	N06 - N02	5.8	17	At-Grade and Tunnel
	N93 (Wolf Trap) -N02	3.8	17	At-Grade and Tunnel	N02 - K98	5.7	17	At-Grade and Aerial
	N02-K98	3.9	17	Aerial and At-Grade				
J / C Line	J03-J01	7.4	13	At-Grade	J02 - J03	3.9	13	At-Grade
	C15-C07	6.9	31	At-Grade and Aerial	J02-C13, C15-C13	4.6	31	At-Grade and Aerial
	C07-C05	2.3	11	Tunnel	C13 - C09	4.6	31	At-Grade and Aerial
					C09-C05, C05-K02	5	30	Tunnel and At-Grade
L Line	L-LINE	3.9	15	Aerial	*Included in F02-F03 Segment			

*Million Gross Tons (MGT)

Figure 3: Comparison of Track Inspection Territories, 2015 and 2016

Track inspection in underground sections is generally more difficult than outdoor track inspection. Visibility is poor; installed tunnel lighting is often dim or obscured by dust. Direct fixation track, characteristic of underground sections, is more complicated to inspect. The underground corridors in the Metrorail system typically have higher train frequencies and elevated catwalks, which makes clearing the track a more arduous process.

Before 2006, each track inspector was certified through the RWP training program in place at that time, and worked under individual train detection, so both inspectors were inspecting track. After a series of accidents, which resulted in several worker fatalities between 2006 and 2009, this policy was changed to require one inspector to act as a watchman, whose sole duty is to watch for oncoming trains – not to inspect track. The other inspector of the two-person team is solely responsible for the visual inspection of a given territory. Roles are typically switched mid-week. The impacts of this policy change on the quality of track inspection are the focus on FWSO's SMI finding R-4-28-a, and FWSO and WMATA have been working cooperatively on this issue for the past several months.

Following an inspection, the track inspectors complete and file a daily inspection record of their activities and associated work activities. The form is included as Figure 4-1, section 4.1.1 of the TRST 1000 Manual. Further, track inspectors are required to maintain the Maximo database by "entering and modifying defect records as defects are found and progress in deterioration." (TRST-1000 3.1.1.4)

Per Operations Administrative Procedure (OAP) 208-01, track supervisors are required to review the daily inspection reports and conduct three field checks per week. FWSO's interviews and observations confirmed that track supervisors historically have been unable to complete the three weekly field checks for track inspection teams under their charge. Also, this process is not formalized in a way that ensures active oversight and monitoring of track inspectors. For example, the track supervisor can complete field checks alone, negating the opportunity for training, mentoring and discussion with track inspectors regarding specific track conditions and the progress of deterioration for specific components in their territories.

3.3 Track Maintenance

TKMN is responsible for maintaining all mainline track, special track work and yards to a state of good repair. Work is typically assigned based on descending order of priority. If track inspectors find a defect during their walks, corrective action is required and varies, up to the suspension of train movement over a section of track, depending on the condition. If an inspection report notes a deficiency or defect, the technicians supporting TRST are required to enter a new Work Order, using WMATA's Asset Management tool (Maximo) and assign it a Work Order Priority on a scale of 0 to 3. (Priority 0 is the most severe and requires track to be removed from service for corrective maintenance. Priority 1 requires speed restrictions until repair, Priority 2 requires monitoring and a possible speed restriction under certain circumstances, and Priority 3 indicates track in serviceable condition and requires no action.)

TKMN then reviews the work order. Per TRST 2000, page 46, a maintenance manager is required to verify the condition and schedule work to address the deficiency or defect. Both OAP 208-01 and TRST-1000 2.10.1 require track inspection reports to be saved for five years. This is accomplished through use of a shared network drive and database within TRST.

WMATA's amended Final Investigation Report on the August 6, 2015 D-Line Curve 306 Derailment indicated that, while corrective maintenance is ongoing, preventive maintenance, including activities to tighten bolts and clear drains, is "on the back burner." It also stated that senior mangers within TKMN believe that, in obtaining track rights, "priority is given to meeting high-level goals, such as replacing a certain number of ties or fasteners, which limits the ability to dedicate resources to Preventive Maintenance activities, such as verifying and correcting deficiencies identified by track inspectors."

During both the FWSO's SMI and the FWSO's track integrity investigation, the FWSO found that TRST as a department has difficulty completing all of the open work orders in the track time allotted to its maintenance crews. As of May 1, 2016, TRST had 13,954 track defects logged into Maximo in various stages of being open for track corrective maintenance, with 17,780 total

defects being tracked by TRST, including structures. The earliest open work orders date from 2008, while the majority of open work orders date from 2015 and 2016.

Specifically for track, Maximo showed:

- 42 Priority 1 Defects (Black/Red)
- 5,536 Priority 2 Defects (Yellow)
- 8,371 Priority 3 Defects (Green)

TRST addresses all Priority 1 Defects that impact the speed of trains as a priority. Generally, Track and Structures personnel are able to address these items in a timely manner (2 hours to 1 week). A daily speed restriction report is distributed to monitor what Priority 1 defects are still current and which defects have been cleared.

Priority 2 defects generally do not generally require speed restrictions, but do require repair. Typical items include battered rail, wheel burns on rail, side wear, top wear, minor chipping, corrugation, missing third rail cover boards, and leaks. Priority 2 defects also must be constantly monitored because, individually, or in combination at a specific location, they can escalate into Priority 1 conditions that require speed restrictions. Priority 3 Defects indicate minimal wear and do not require repair, but do require monitoring for further degradation.

While WMATA attempts to address deficiencies or defects identified as Priority 1 or 2 as quickly as possible with available maintenance crews, these crews also perform other tasks, such as supporting the Capital Projects group, and are not always available to address these conditions. During the SMI, through March 2015, TRST reported 3,263 Priority 2 Defects. This shows a marked increase in documented Priority 2 Defects tracked in Maximo over the last year.

TRST relies heavily on Maximo to track assets, preventive maintenance schedules and work orders, among other features. The Inspections and Maintenance groups both utilize Maximo to enter, update and close Work Orders, list tasks completed that are associated with the Work Order and track employees assigned to the Work Order. Through the SMI, the FWSO also issued several findings (R-7-40-a through R-7-40-c and R-7-41-a) that WMATA is working to address, regarding the quality of the data in Maximo. During the FWSO's investigation, WMATA's technical leadership confirmed that their level of confidence in the accuracy of the data currently in Maximo is approximately 75 percent. To address this situation, WMATA has hired a contractor to perform an entirely independent track inspection of the Metrorail system to re-populate the Maximo system with an accurate and consistently inputted baseline at the conclusion of the SafeTrack project. TRST also has established a Rail Analytics Group to carefully review and monitor Maximo data entry, and to run and validate reports. New training is also being developed for maintenance personnel on using Maximo and entering data.

4.0 Findings and Required Action

FWSO organizes its discussion regarding the findings and required actions from its SMI at WMATA Metrorail into four over-arching categories of safety critical concerns:

- Category 1: Track Inspection Resources and Training
- Category 2: TRST 1000 Manual
- Category 3: Track Quality Oversight
- Category 4: Track Construction and Maintenance

Within these categories, FWSO makes specific findings based on the results of interviews, document and records reviews, field observations, and independent inspections, testing and measurements. In Safety Directive 15-1, FWSO issues required actions that WMATA must take to address the findings described in each category of this SMI report. Safety Directory 15-1 also establishes required response times, a process for FWSO approval of work plans, and the FWSO's approach to the monitoring of the implementation WMATA's work plans.

4.1 Track Inspection Resources and Training

FWSO's investigation found that the resources and training devoted to track inspection could be significantly improved to enhance effectiveness. FWSO's team identified 4 findings regarding this topic.

4.1.1 Situation

TRST does not provide its own initial training for track maintainers and track inspectors, but relies on WMATA's technical training division, which is currently undergoing re-organization. TRST personnel have expressed concerns regarding the quality of this training and the knowledge and expertise of some of the instructors on track-specific issues. TRST also uses contractors to provide specialty training and senior track inspectors support on-the-job training. In response to concerns previously discussed with the FWSO, WMATA is now working with the University of Tennessee to develop new track inspection training for inspectors and supervisors.

- **Finding 1: Track inspectors receive inadequate training.**

During inspections conducted as part of the track integrity investigation, FWSO inspectors noticed a lack of comprehension of TRST 1000 manual requirements among some track inspectors, as well as low ability to practically apply the standards. As an example, an FWSO inspection team encountered an issue with lack of knowledge regarding the application of third rail gauge threshold measurements. Specifically, at one location where the rail exhibited equipment striking the third rail, employees indicated that the third rail gauge was measured from the field side of the rail. The TRST 1000 indicates measurement from the gauge side of the near rail.

More significantly, during the course of the investigation, and in subsequent follow-up inspections, FWSO inspectors found deficient track conditions requiring speed restrictions that

were missed by track inspectors, including instances of missing direct fixation or DF fasteners (up to 456 inches between effective DF fasteners) that should have been already noted and repaired. In other instances, questions regarding the cause or source of specific defects, from wheel burns, to spalling and corrosion, were incorrectly identified and the typical progression patterns and timelines for common defects were also not well understood. Many of the track inspectors encountered appeared to be inadequately trained with little or no hands-on-training.

- **Finding 2: There is insufficient time for track inspection.**

As of June 2016, WMATA has 54 certified track inspectors and 5 trainees (planned for Dulles Phase II), for a total of 59 track inspectors. Eight (8) supervisors oversee the 59 track inspectors from four locations (Branch Avenue, Alexandria, New Carrolton and Brentwood). Track inspection teams are assigned a permanent territory (they are not deployed to different areas week to week) based on an annual pick. They are responsible for inspecting each track twice per week, for a total of four track walks per week. Another day is used to inspect special trackwork, yard track, or tend to other maintenance concerns.

In response to FWSO's SMI finding R-4-28-a, regarding the impact that the change in inspection practices, with one inspector now serving as a watchman, has had on the overall level of resources devoted to inspections and their quality, WMATA is currently evaluating three-man teams, consisting of one watchman-lookout and two inspectors in the high tonnage, high train frequency D98 – Rosslyn corridor, to enhance safety and the quality of inspection.

FWSO's investigation confirmed that WMATA's two-person inspection teams typically work from 7:30am to 4:00pm on weekdays with 4 hours of actual inspection time available between 10:00am and 2:00pm. Track inspectors use safety walks and also walk on the right-of-way when conducting inspections. Track inspectors must clear for passing trains every 6 to 12 minutes, and typically spend between 20 and 40 minutes of their 4 hours of inspection time clearing for trains and waiting for trains to pass.

In essence this means that one inspector spends 3½ hours inspecting 4 to 5 miles of track each day while under the constant distraction of passing trains and the need to clear. The FWSO appreciates that WMATA has already modified its track territories and is considering the use of 3-person inspection teams in the core in response to previous FWSO findings. However, the constraints placed on this inspection activity clearly limit its effectiveness. There is not the time to closely examine specific conditions or concerns or to use tools, such as rail wear gauges or Geismar gauges (retrieved from "Job Boxes" at different locations within the system).

Also, per the Operations Administrative Procedure (OAP) 208-01, track supervisors are required to review the daily inspection reports and conduct three field checks per week. FWSO's interviews and observations confirmed that track supervisors historically have been unable to complete the three weekly field checks for track inspection teams under their charge, due to a lack of time and resources.

WMATA's inspection plan must ensure sufficient time to inspect all tracks and special trackwork to the standard specified in the TRST 1000 Manual, and also provide ample time to

ensure performance of required supervisory inspections and inspections required to support the scheduling of maintenance work. WMATA's track inspection plan must analyze the time required to conduct visual inspection of tracks in accordance with WMATA's track safety standards, and ensure that high priority tracks are inspected as frequently as necessary to identify and monitor the progression of specific defects and combinations of conditions. WMATA's inspection plan also must consider the characteristics of different tracks.

- **Finding 3: Excessive wear and deficient crosstie condition in special trackwork is not being identified and addressed.**

The FWSO's team noted the difficulty of accessing certain locations, including turnouts, crossovers and other special trackwork during revenue service with limited inspection windows. While twice weekly walking inspections are supposed to include special trackwork in a given track inspector's territory, interviews and observations indicated that track inspectors do not typically inspect these areas, and rely instead on the detailed monthly inspections.

Throughout the track integrity investigation, the FWSO's team found missing bolts and excessive wear in switches and crossovers, and deficient wood crossties in ballasted sections throughout the system. Further, the FWSO's team found that detailed monthly inspections of switches and turnouts ranged in quality and thoroughness.

More recently, in response to the July 29, 2016 derailment, the FWSO found poor crosstie condition, loose and missing fasteners, and evidence of excessive lateral rail movement. These conditions clearly exceeded allowable safety parameters specified in WMATA's track safety standards, and were not identified or addressed by WMATA prior to the derailment.

- **Finding 4: The TGV is underutilized as part of WMATA's track inspection program.**

Failure in a track segment generally follows a process from an undetected crack into defect, from defect to a failure, and from a failure to breakage. Automated technology can provide a useful tool in identifying defects earlier and accurately monitoring their progression. WMATA possesses its own TGV, and is working to bring all automated testing in-house.

As of June 2016, WMATA has set an internal policy of using the TGV a minimum for four (4) times per year for track geometry and two (2) times per year for ultrasonic testing of the entire system. WMATA has already exceeded this annual testing policy on certain segments of the Red Line, and continues to receive new value from this vehicle as it integrates TGV runs into SafeTrack and on-going monitoring of other track locations.

During the track integrity investigation, between late March and mid-April, FWSO team members accompanied WMATA's TGV inspection team for ultrasonic inspection and track geometry inspection. During the ultrasonic testing ride, no significant defects (red or black) were found. Although the vehicle was stopped and reversed on several occasions to re-analyze data locations, only two (2) locations required on-the-ground, hand verifications for potential deficiencies cited; however, none were found. During the track geometry ride, WMATA

observed several conditions that required immediate corrective action. (A chase team was available in the case an out of service defect was captured and verified.)

As of June 2016, WMATA had five (5) employees who are certified to analyze the ultrasonic technical data and hand-verify potential deficiencies identified by the TGV. Only one of these certified employees actively operates the TGV and serves on the TGV crew. (He is also responsible for the UT specialized components and maintenance for this area of the test vehicle.) WMATA is working to get other TGV crew members certified.

As a result of the August 6, 2015 derailment, WMATA recently completed new guidelines for its TGV testing program. WMATA is also working to reduce the time required to generate results and ensure that information is provided to the Engineering Department immediately after testing.

While WMATA is making greater use of the TGV, FWSO finds that WMATA's overall track inspection program would benefit from expanding TGV use into full-time deployment. Establishing a full-time TGV crew and a full-time TGV testing schedule, and expanding resources for maintenance and calibration of the TGV, and the continual annual training and certification of the TGV crew, will supplement WMATA's visual inspection program and enhance opportunities to identify and resolve defective track conditions before an incident.

4.1.2 Findings and Required Actions

Metrorail Category 1: Track Inspection Resources and Training			
Findings		**Required Actions**	
Finding 1	Track inspectors receive inadequate training.	T-1	WMATA must develop additional track inspection training and certification requirements, and expand mentoring.
Finding 2	There is insufficient time for track inspection.	T-2	WMATA must establish a new track inspection plan that expands time available for track inspection through additional inspection shifts (i.e., evening and nighttime) and more frequent inspections of priority locations.
Finding 3	Excessive wear and deficient crosstie condition in special trackwork is not being identified and addressed.	T-3	WMATA must commit adequate resources and technically qualified personnel to the inspection of special trackwork and the completion of required corrective maintenance.
Finding 4	The TGV is underutilized as part of WMATA's track inspection program.	T-4	WMATA must expand the use of the TGV in its track inspection program, and ensure the training and certification of the TGV crew.

4.2 TRST 1000 Manual

4.2.1 Situation

The *TRST 1000 Track Maintenance and Inspection Manual*, Revision 6, January 1, 2015 is 425 pages in length, and includes in-depth information on track construction, maintenance and safety standards, requirements, and track engineering theory used at WMATA. Combining

construction, maintenance and safety standards together in one document makes the manual confusing for track inspectors, who need clear statements regarding inspection safety limits. Inspectors do have a field inspection manual, which is a selection of pages and tables excerpted from the full manual, but it also includes maintenance and construction information which is not relevant to inspection, and which confuses assessments that must be straight-forward and unambiguous from a safety perspective. Also, for track maintenance managers, the TRST 1000 manual can be confusing in terms of establishing clear safety priorities for maintenance work, and assessing combinations of conditions with a greater potential risk than the ranking of their individual elements may indicate.

- **Finding 5: The TRST 1000 Manual is not a field document focused on inspection safety limits.**

WMATA needs a track inspection manual that specifies safety limits and the specific actions that should be taken by the inspector if track conditions are identified outside those safety limits. The TRST 1000 manual contains much "nice to know" information on track engineering principles and schematics. This information is not preemptively necessary for mission critical safety, and inadvertently creates a barrier in getting to the information most essential for track inspection. Safety limits are present in all of the rules reviewed; however, they are lost in the overabundance of data presented making the usage of this manual onerous in its present form.

Further, for consistent application of any safety limit, there cannot be two contrasting criterion for field inspectors and supervisors to apply. The TRST 1000 Manual includes broad statements about both maintenance and safety standards that confuse understanding regarding minimum conditions that must be observed in the field prior to the issuance of a speed restriction. There should be one limit for all employees looking at safety items for top-to-bottom consistency.

The TRST 1000 manual also contains outdated references and requirements, which must be corrected. In addition, critical information regarding the filing and management of inspection reports is outdated, and needs to be corrected.

Finally, the TRST 1000 Manual does not reflect how the Track Geometry Vehicle or TGV is actually used at WMATA to support track inspection. For example, the TRST 1000 manual currently requires track inspectors to conduct "a detailed walking inspection of super elevation and gauge on all curves and spirals at least every 4 months." However, WMATA track inspectors do not perform this activity, instead the TGV is used for assessing super elevation and gauge on curves and spirals. Also, as WMATA transitions away from contractors to operating and managing its own TGV program, the agency needs additional procedures to clarify how it will manage scheduling of TGV run-throughs that may be missed while the TGV is being maintained or calibrated, or while it may be out-of-service pending repair or upgrade.

- **Finding 6: WMATA does not have a clear process in place for track inspectors and supervisors to impose and remove speed restrictions.**

The procedure for WMATA track inspectors and supervisors to use the TRST 1000 manual to assess track conditions and clearly identify which conditions warrant speed restrictions is not

well understood by track inspectors or track supervisors, and requires additional support from track engineering.

The TRST 1000 manual currently states, "Speed restrictions are to be applied only when the components are defective from a safety point of view (i.e. when the safety of the track may be compromised). For components, which are defective from a maintenance point of view, speed and/or other restrictions are imposed at the discretion of the track supervisor." This statement has enormous impact on WMATA's track inspectors. Some track inspectors encountered by the FWSO teams in the field were reluctant to place speed restrictions due to fear of punitive redress or the difficulty of arguing a situation based on the TRST 1000 manual.

During the track integrity investigation, the FWSO team members conducted independent inspections with WMATA's track inspectors and supervisors and found inconsistent practices regarding conditions that would necessitate a speed restriction. Further, the lack of an appeal or "good faith challenge" process means that track inspectors with safety concerns have no redress if the supervisor does not agree. In some instances, due to the size of the WMATA system, supervisors are not available to immediately review track conditions in the field, and may make assessments based on photographs or videos. Track Engineering is currently only called in to review a situation in rare instances, but provides a potentially valuable resource to mediate challenges and address concerns regarding track conditions.

4.2.2 Findings and Required Actions

Metrorail Category 2: TRST 1000 Manual			
Findings		**Required Actions**	
Finding 5	The TRST 1000 Manual is not a field document focused on inspection safety limits.	T-5	WMATA must revise the TRST 1000 manual, or establish a separate track inspection manual, focused on inspection safety limits.
Finding 6	WMATA does not have a clear process in place for track inspectors and supervisors to impose and remove speed restrictions.	T-6	WMATA must establish a clear process for imposing and removing speed restrictions.

4.3 Track Quality Oversight

FWSO's investigation found that track maintenance quality and oversight could be significantly improved. FWSO's team identified 4 findings regarding this topic.

4.3.1 Situation

As discussed in Section 3 of this report, the results of track inspections are documented on daily inspection reports, which record track inspector activities and observations. These reports are entered into WMATA's Maximo work order system. Paper inspection records are retained for cross-reference.

If track inspectors find deficiencies or defects, a new Work Order must be opened in Maximo and assigned a Work Order Priority. The Work Order is then supposed to be reviewed by the Track Maintenance branch. Per TRST 2000, a maintenance manager is required to verify the condition and schedule work to address the deficiency or defect.

- **Finding 7: WMATA fails to use inspection data to inform and prioritize track maintenance.**

TKMN maintenance managers, almost entirely on their own, are required to capture deficiencies and defects from the TKIN branch and relay the appropriate priority level to their TKMN assistant superintendents for work scheduling. In interviews conducted with FWSO's teams, it was reported that field verification is not routinely completed regarding the defects identified by track inspectors, due to time and resource limitations.

And, while track inspectors, over time, are required to maintain the Maximo database by "entering and modifying defect records as defects are found and progress in deterioration." (TRST-1000 3.1.1.4), FWSO's investigation found that most reports in Maximo do not appear to have been updated or changed after their date of creation. Therefore, maintenance managers may not have the most current information in evaluating and scheduled necessary work.

WMATA's report on the August 6, 2015 derailment highlights the organizational separation of the Track Inspection and Maintenance branches within TRST. As evidenced in the revised investigation report, track inspectors routinely reported a lack of knowledge regarding how the other operational group functions and how their inspection reports are used. Track Inspectors reported rarely receiving any feedback or questions about any of their reports. Some maintenance managers reported contacting inspectors for more information about a reported condition, but that this was not a formal policy or practice.

The FWSO finds that additional coordination between TKIN and TKMN would enhance the likelihood that maintenance work scheduled addresses the highest priority issues and concerns.

- **Finding 8: Maintenance managers require additional training and resources to act on inspection data.**

Currently, maintenance managers are among the newest managers in the TKMN branch and have varying levels of training and experience in track repair/maintenance and general management. Maintenance managers receive little formal training curriculum upon their hiring or promotion, and WMATA has little written guidance regarding how this process should be managed, and how time constraints and the lack of field verification should be factored into the scheduling of work. Track inspection reports in Maximo may not be updated, or may not fully reflect progression of deterioration in track system components.

- **Finding 9: Current inspection and maintenance activity does not adequately address tunnel drainage system.**

The FWSO's teams believe that the single most valuable action WMATA could take to preserve its track integrity is to place a clear priority on maintaining and unclogging drains in tunnels. During May, when the drains were unclogged and restored to good condition on a stretch of the Red Line between Medical Center and Friendship Heights, WMATA employees informed FWSO that this type of work on the drainage system, including mud removal and clearing of drains, had not been performed in many years. FWSO's team found that after this work began, there was a substantial improvement in water remediation and dryness in the tunnel. Given the corrosive and deleterious effects of water on track infrastructure, the FWSO finds that drain maintenance should be a much higher priority in WMATA's overall track inspection and maintenance program.

- **Finding 10: Additional supervision is needed for both track inspection and track maintenance activities.**

A consistent finding through the FWSO's investigation is that, given the size of the WMATA system and challenges of accessing the right-of-way, WMATA's TKIN and TKMN management and supervision teams are significantly understaffed. Field checks and verification activities, for both inspection and maintenance activities, required in OAP 208-01, are not completed due to a lack of time and resources. Records reviews and observations of track inspectors performing their work indicate that "areas of concern" with the track structure, shared with FWSO's teams, are identified, but work is not scheduled to address them. Oversight is limited for track inspectors and track maintainers, and FWSO's team identified quality issues with both groups that could be readily addressed with additional field supervision, mentoring and discussion with track inspectors regarding specific track conditions and the progress of deterioration for specific components in their territories.

4.3.2 Findings and Required Actions

Metrorail Category 3: Track Quality Oversight			
Findings		**Required Actions**	
Finding 7	WMATA fails to use inspection data to inform and prioritize track maintenance.	T-7	WMATA must develop a formal procedure and protocol to ensure the maintenance managers and track inspectors share information and jointly establish maintenance priorities.
Finding 8	Maintenance managers require additional training and resources to act on inspection data.	T-8	WMATA must provide additional training and resources to maintenance managers related to the use of inspection information to establish maintenance priorities.
Finding 9	Current inspection and maintenance activity does not adequately address tunnel drainage system.	T-9	WMATA must ensure that track inspectors and maintenance managers prioritize drainage defects.
Finding 10	Additional supervision is needed for both track inspection and track maintenance.	T-10	WMATA must provide additional supervisory staff or contractors to oversee track inspection and track maintenance activities and ensure conformance with WMATA track safety standards.

4.4 Track Construction and Maintenance

FWSO's investigation found track construction and maintenance issues to be resolved. FWSO's team identified 3 findings regarding this topic.

4.4.1 Situation

The TRST 1000 manual states that direct fixation or DF fastener stud anchor bolts from a "maintenance standpoint" shall not exceed more than 3 inches above the rail base. FWSO's investigation team found numerous instances where bolt lengths exceeded 3 inches, where bolts had been cut off, and where bolts were improperly installed. FWSO's investigation team also identified many instances of missing fasteners in direct fixation track.

- **Finding 11: WMATA does not apply the same quality control testing program to its force account installed fasteners that it would apply to those installed by a contractor while building a new line segment.**

FWSO's investigation team confirmed inappropriate installation on stud anchor bolts and fasteners in direct fixation track. FWSO's investigation team recognizes the difficulty and time required to manage transverse and longitudinal invert rebar when installing anchor bolts. When transverse rebar is encountered during the drilling operation, a new hole location is to be selected and new layout measurements taken from that point to avoid the rebar installation pattern. Longitudinal rebar if in the path way of the rail cannot be avoided and must be drilled through to achieve the minimum embedment. (At WMATA, finder studs were installed during the original invert construction to identify start points of rebar patterns in order to avoid the transverse rebars. Pacometers also can be used to find and help avoid embedded rebar.)

FWSO's investigation team observed construction contractors cutting anchor bolts off rather then relocating drilled holes or drilling through the rebar. FWSO noted numerous instances of cut bolts in track beds. FWSO's inspectors also observed incorrect installation procedures to avoid longitudinal rebar. Finally, the FWSO investigation team also confirmed that TRST does not conduct the 6,000 lb. unrestrained pull tests required during new construction. This test, required for new construction, determines whether the anchor bolts have achieved the design hold down strength for the track fasteners.

FWSO's investigation team also found that the vast majority of bolted rail joints in direct fixation track or crossties with resilient fastening systems are missing rail clips. While not an immediate safety concern such a condition creates a weak point when other types of more critical defects occur at the same spot.

- **Finding 12: In certain instances, WMATA uses welding practices inconsistent with its construction standards to install cables to ensure train control and electrical continuity around mechanical joints.**

FWSO's inspection team found many CADWELD C bonds on the heads of rail that were broken. A C bond is small gauge rail head bond, used in pairs as power bonds at rail joints, welded on both ends to the field side of the heads of the rails. C bonds support cross-bonding between tracks, providing a connector for the negative return system, and also support the train control system. Because of their location, these C bonds can be broken, frayed or severed in the course of normal train operations. In addition, CADWELD C bonds on rail heads can affect the metallurgical and grain structure of the rail head, making it more prone to cracks. As a result, WMATA revised its design and construction specifications several years ago to replace CADWELD C bonds with huck bolted bonds in the webs of the rail to provide a stronger non-welded bond. Huck bolts are compression fasteners that do not frequently break off, and do not compromise return current flow or the integrity of the rail.

Huck bolted bonds do require special components for installation, and under certain conditions, WMATA's ATC Branch, when making emergency repairs or addressing priority repairs, uses the CADWELD C bonds by default. These bonds are then marked for replacement with huck bolted bonds. However, FWSO team members found numerous instances where CADWELD C bonds that had not been replaced with huck bolts as required, and were broken, frayed or otherwise damaged.

4.4.2 Findings and Required Actions

Metrorail Category 4: Track Construction and Maintenance			
Findings		**Required Actions**	
Finding 11	WMATA does not apply the same quality control testing program to its force account installed fasteners that it would apply to those installed by a contractor while building a new line segment.	T-11	WMATA must develop a special inspection and repair plan to address inappropriate stud bolt installation and missing fasteners, and ensure track maintainers and contractors are trained in stud bolt installation and rail clip installation, and that work is adequately overseen.
Finding 12	In certain instances, WMATA uses welding practices inconsistent with its construction standards to install cables to ensure train control and electrical continuity around mechanical joints.	T-12	CADWELD C-bonds must be identified and replaced with huck bolted cables in the webs of the rail as specified in WMATA's standards.

Attachment A: Findings and Required Actions Matrix

Metrorail Category 1: Track Inspection Resources and Training			
Findings		**Required Actions**	
Finding 1	Track inspectors receive inadequate training.	T-1	WMATA must develop additional track inspection training and certification requirements, and expand mentoring.
Finding 2	There is insufficient time for track inspection.	T-2	WMATA must establish a new track inspection plan that expands time available for track inspection through additional inspection shifts (i.e., evening and nighttime) and more frequent inspections of priority locations.
Finding 3	Excessive wear and deficient crosstie condition in special trackwork is not being identified and addressed.	T-3	WMATA must commit adequate resources and technically qualified personnel to the inspection of special trackwork and the completion of required corrective maintenance.
Finding 4	The TGV is underutilized as part of WMATA's track inspection program.	T-4	WMATA must expand the use of the TGV in its track inspection program, and ensure the training and certification of the TGV crew.
Metrorail Category 2: TRST 1000 Manual			
Findings		**Required Actions**	
Finding 5	The TRST 1000 Manual is not a field document focused on inspection safety limits.	T-5	WMATA must revise the TRST 1000 manual, or establish a separate track inspection manual, focused on inspection safety limits.
Finding 6	WMATA does not have a clear process in place for track inspectors and supervisors to impose and remove speed restrictions.	T-6	WMATA must establish a clear process for imposing and removing speed restrictions.
Metrorail Category 3: Track Quality Oversight			
Findings		**Required Actions**	
Finding 7	WMATA fails to use inspection data to inform and prioritize track maintenance.	T-7	WMATA must develop a formal procedure and protocol to ensure the maintenance managers and track inspectors share information and jointly establish maintenance priorities.
Finding 8	Maintenance managers require additional training and resources to act on inspection data.	T-8	WMATA must provide additional training and resources to maintenance managers related to the use of inspection information to establish maintenance priorities.
Finding 9	Current inspection and maintenance activity does not adequately address tunnel drainage system.	T-9	WMATA must ensure that track inspectors and maintenance managers prioritize drainage defects.
Finding 10	Additional supervision is needed for both track inspection and track	T-10	WMATA must provide additional supervisory staff or contractors to oversee track inspection and track maintenance

	maintenance.		activities and ensure conformance with WMATA track safety standards.
Metrorail Category 4: Track Construction and Maintenance			
Finding 11	WMATA does not apply the same quality control testing program to its force account installed fasteners that it would apply to those installed by a contractor while building a new line segment.	T-11	WMATA must develop a special inspection and repair plan to address inappropriate stud bolt installation and missing fasteners, and ensure track maintainers and contractors are trained in stud bolt installation and rail clip installation, and that work is adequately overseen.
Finding 12	In certain instances, WMATA uses welding practices inconsistent with its construction standards to install cables to ensure train control and electrical continuity around mechanical joints.	T-12	CADWELD C-bonds must be identified and replaced with huck bolted cables in the webs of the rail as specified in WMATA's design and construction standards.